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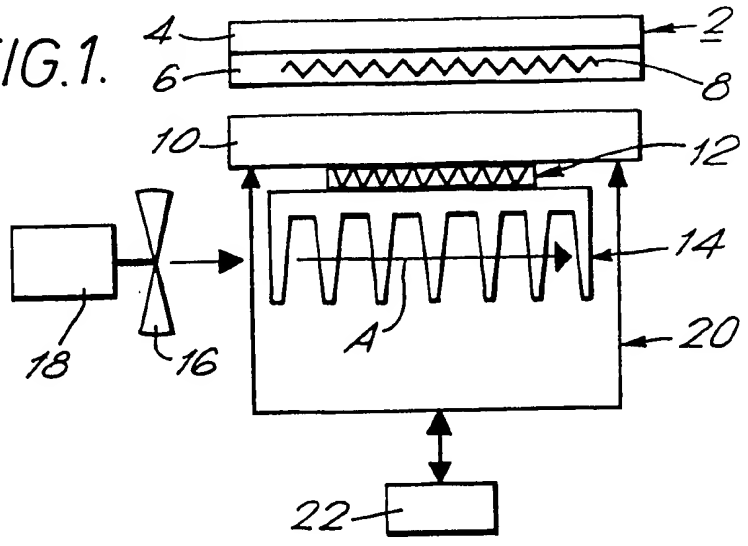
(54) **Apparatus and method for heating and/or cooling reaction vessels**

(57) Apparatus for cyclically heating and cooling reaction vessels mounts the reaction vessels in a support member (2) which comprises a reaction plate (4) supported on a heated block (6). This heats material to be treated, such as blood or DNA in the reaction plate (4). A cold block (10) is mounted beneath and spaced below the heated block (6). On its surface remote from the heated block (6), the cold block 10 carries a plurality of Peltier elements (12) supplied with electrical current such that the top surface thereof becomes cold. During heating of the material in the reaction plate (4) by the heated block (6) the cold block (10) is maintained spaced therefrom. When it is required to cool the material in the reaction plate (4), the heating of the heated block (6) is ceased, and then the cold block (10) is moved into contact with the heated block (6) to cool the reaction plate (4).

FIG.1.



At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

The claims were filed later than the filing date within the period prescribed by Rule 25(1) of the Patents Rules 1990.

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FIG.1.

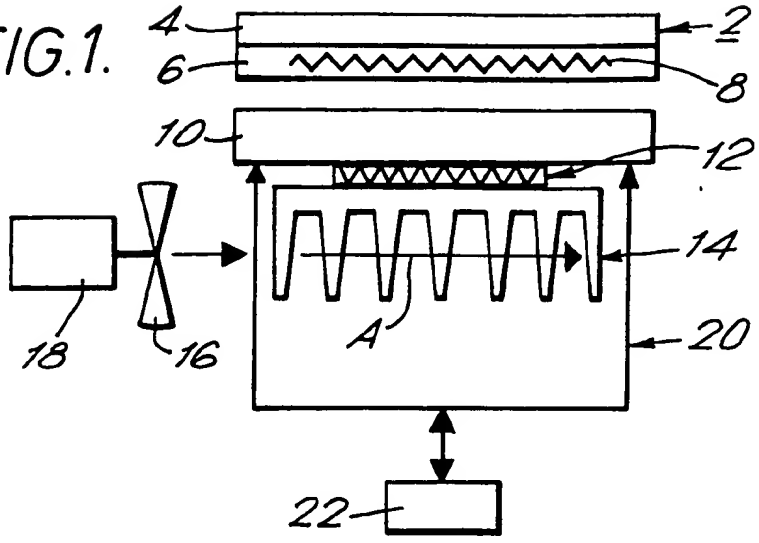
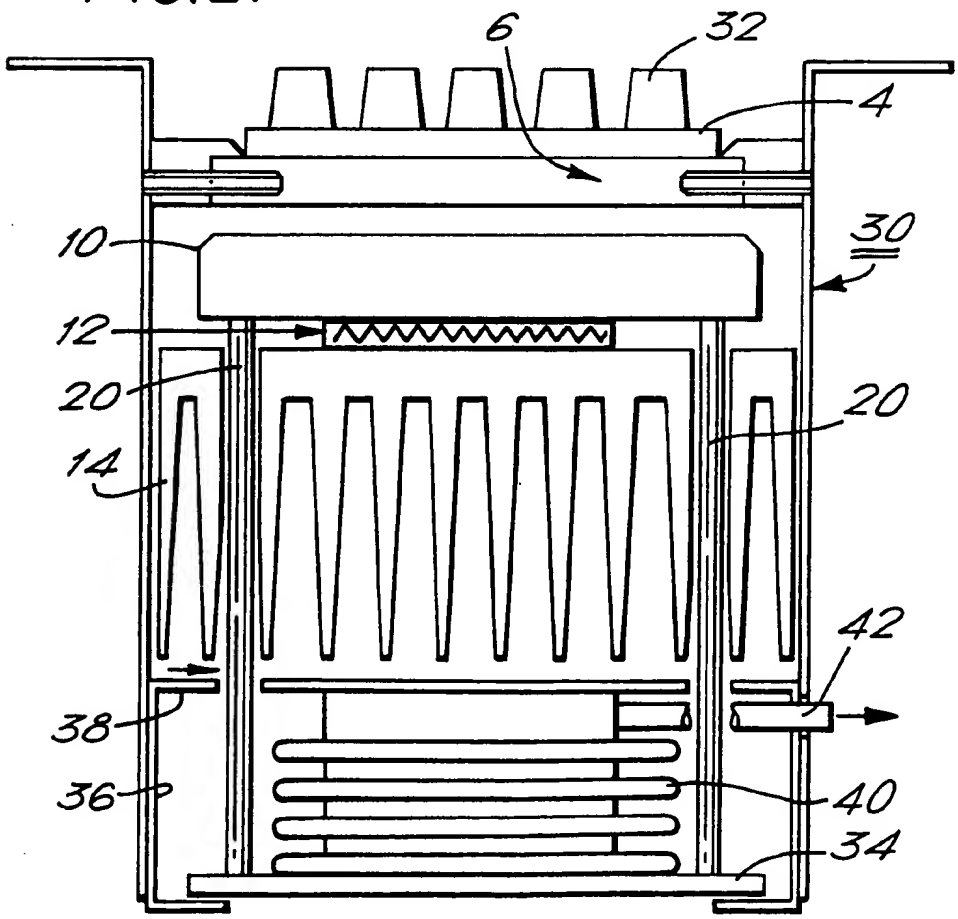


FIG.2.



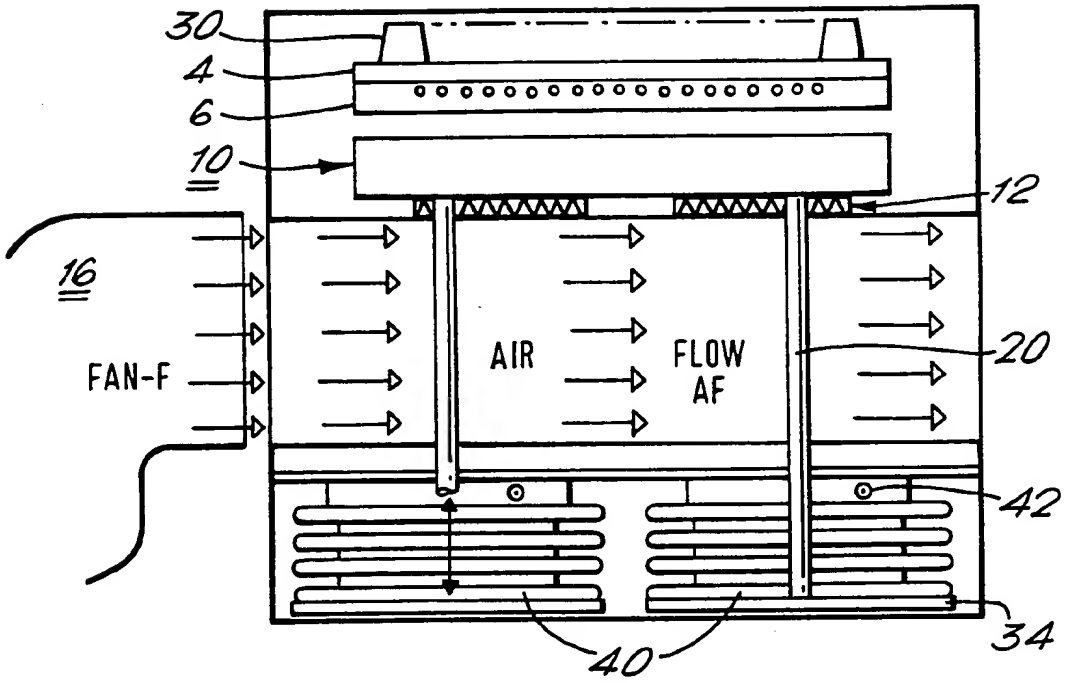


FIG. 3.

APPARATUS AND METHOD FOR HEATING AND/OR COOLING REACTION VESSELS

The present invention relates to an apparatus and method for heating and/or cooling reaction vessels.

It is frequently necessary to subject material, for example, blood or genetic material, to consecutive heating and cooling cycles. Presently, apparatus using Peltier elements to provide at least the cooling cycle is provided. In this respect, Peltier elements may be used both to heat and to cool the material by reversing the current flow therethrough. However, the temperatures required on heating may exceed the maximum temperature of the Peltier elements. Alternatively, the Peltier elements may be used simply to provide cooling, with the samples being heated by alternative, means. In this case the elements are, of course, switched off during the heating phase. However, reversing the current through Peltier elements, or switching them on and off subjects them to thermal shock and diminishes their life expectancy.

It is an object of the present invention to provide a method and apparatus for heating and/or cooling reaction vessels which reduces the problems identified above.

According to a first aspect of the present invention there is provided apparatus for heating and/or cooling reaction vessels comprising a thermally conductive support member for said reaction vessels, a first thermally conductive block, and means for causing relative movement between said first thermally conductive block and said support member between a first position in which said first block and said support member are in thermal contact, and a second position in which said first block and said support member are spaced apart, and further comprising first means

for heating and/or cooling said first thermally conductive block.

The term "thermally conductive" is used throughout this specification to refer to a member which is at least partially thermally conductive and/or has a thermally conductive path therethrough.

In a preferred embodiment, said first means for heating and/or cooling said first thermally conductive block comprises first cooling means arranged to cool said first thermally conductive block. Thus, in this embodiment, the first relative position of said first block and said support member is a cooling position in which the thermal contact between said first block and said support member acts to cool said reaction vessels. Similarly, said second position, in which said first block and said support member are spaced apart, is a non-cooling position.

Said first cooling means may comprise a plurality of Peltier elements arranged to be in thermal contact with said first thermally conductive block, at least in the second position of said first block and support member. Preferably, a surface of said first block remote from said support member is arranged to contact a first surface of said plurality of Peltier elements. Said plurality of Peltier elements are provided with contact means for connection to a power source whereby electrical power may be applied to said elements such that said first surface thereof is cooled. Preferably, a heat sink is provided and is arranged, at least in said second position of said first block and said support member, to be in contact with a second surface of said plurality of Peltier elements remote from said first surface. Air flow generating means are preferably provided for causing an air flow through or across said heat sink.

The apparatus defined above may be used to cool reaction vessels supported by said support member. Such reaction vessels might, for example, be at ambient temperature, or may have been subjected to pre-heating.

In a preferred embodiment, said thermally conductive support member comprises a second thermally conductive block, and second means are provided for heating said second thermally conductive block.

For example, the second heating means may be an electrical heater. This electrical heater may be a resistance wire provided in the second thermally conductive block, and/or a resistive film deposited onto an insulating substrate mounted within said block.

Where the support member includes a heatable second thermally conductive block it will be appreciated that the apparatus may be used for subjecting reaction vessels to heating and cooling cycles. In this respect, the first thermally conductive block and the support member are arranged in their second spaced apart position when said second thermally conductive block is heated. This ensures that heat is not applied to the cooling surface of the Peltier elements. However, electrical power may be applied to said Peltier elements continuously, even when the reaction vessels are being heated, so that a stable state is attained. As the Peltier elements are not subjected to violent changes in the applied power, potential thermal shock on the Peltier elements is reduced and their life expectancy is increased.

The means for providing relative movement between said first thermally conductive block and said support member may be arranged to move either the support member or the first thermally conductive block, or both of these members.

In a preferred embodiment said support member is supported at a fixed position within a housing. Said first thermally conductive block is mounted within the housing beneath said support member. Said relative movement providing means comprises means for moving said first thermally conductive block between the first, upper, position, in which it contacts the underside of said support member, and the second, lower, position in which it is spaced from said support member.

The lower, heated surface of said Peltier elements is arranged to contact, and may be supported by, a heat sink mounted within the housing. In the second, lower, position of the first thermally conductive block, its lower surface is arranged to contact, and be cooled by, the cold surface of said plurality of Peltier elements.

In a preferred embodiment, the means for moving the first thermally conductive block comprises one or more rods coupled thereto such that lifting or extension of the rods lifts the block to its first position. The rods may be, for example, piston rods and/or may be moved by any appropriate means. In the presently preferred embodiment, the rods are arranged to be lifted and lowered by way of one or more bellows assemblies.

The invention also extends to a method of heating and/or cooling material, the method comprising cooling material in reaction vessels supported by a support member, and the method comprising the steps of cooling a first thermally conductive block, and moving the cooled, first thermally conductive block into contact with said support member such that it is thermally coupled to said reaction vessels and thereby cools them.

Preferably, the first block is cooled by contacting a

surface of said first block remote from said support member with a first surface of a plurality of Peltier elements, and applying current to said elements such that said first surface thereof is cooled. Preferably, a heat sink is arranged in contact with a second surface of said Peltier elements remote from said first surface and air is caused to flow across said heat sink. The first block is cooled when spaced from said support member.

In a preferred embodiment, the method additionally comprises the steps of heating said support member when said first thermally conductive block is spaced therefrom.

In a preferred embodiment, the first thermally conductive block and said support member are arranged spaced apart, and said support member is heated. At the same time electrical current is applied to said plurality of Peltier elements to provide cooling to said first thermally conductive block.

Embodiments of the present invention will hereinafter be described, by way of example, with reference to the accompanying drawings, in which:

Figure 1 shows schematically apparatus for heating and cooling reaction vessels according to the invention,

Figure 2 shows an end view of an embodiment of apparatus of the present invention, and

Figure 3 shows a side view of the apparatus of Figure 2.

The apparatus shown schematically in Figure 1 enables reaction vessels to be cyclically heated and cooled. In this respect, the reaction vessels (not shown) are mounted in or provided by a support member 2 which comprises a reaction plate 4 supported on and affixed to a heated block

6. In this respect the block 6 is a thermally conductive block in which an electrical resistance wire, indicated at 8, is provided. It will be appreciated that the application of electrical current to the resistance wire 8 heats the block 6.

The upper surface of the heated block 6 is in contact with, and supports, the reaction plate 4. This reaction plate may have a number of wells formed alternatively, therein for the receipt of samples. Additionally and/or alternatively, recesses or apertures may be provided in the reaction plate 4 for the receipt of individual test tubes (not shown). Samples of the material to be treated in the apparatus, which may be blood, DNA, or any other material, is received within the wells and/or test tubes. The reaction plate 4 is preferably made of thermally conductive material so that heating the block 6 heats the wells or test tubes forming the reaction vessels supported by the plate 4.

The apparatus also comprises a further thermally conductive block 10 which is arranged to be a cold block. It will be seen that this block 10 is mounted beneath and spaced below the heated block 6. On its lower surface, remote from the heated block 6, the cold block 10 carries a plurality of Peltier elements 12. In known manner electrical current is arranged to be applied to these Peltier elements 12 such that one surface thereof becomes cold whilst the other surface thereof becomes hot. In the apparatus of Figure 1 it is the top surface of the Peltier elements 12, which is in contact with the lower surface of the cold block 10, which is arranged to be cold. The opposite, lower surface of the Peltier elements 12 will thus be the hot surface and, as can be seen from Figure 1, is in contact with, and is preferably affixed to, a heat sink 14. A fan 16 is provided and is powered by an

electric motor 18. When current is applied to the Peltier elements 12, the fan 16 is powered by the motor 18 to produce an air flow, indicated by the arrow A, across the heat sink 14. Thus, the heat sink 14 receives the heat from the hot side of the Peltier elements 12, and this is taken away by the air flow so that the cold side of the elements 12 is maintained cold.

In use, material to be treated, for example, to be heated and/or cooled, is received within the wells or test tubes provided in or by the reaction plate 4. If it is required to heat the material, electrical current is applied to the resistance wire 8 to heat the heated block 6 and hence the material in the reaction vessels. During this process the cold block 10 is maintained spaced from the heated block 6. However, during the heating of the material, current may be applied to the Peltier elements 12, and the fan 16 operated, whereby the cold block 10 is cooled.

If it is required to cool the material in the reaction vessels of the reaction plate 4, whether or not they the material has been heated previously, this can be done very effectively by ensuring that current to the electrical resistance wire 8 is reduced or is no longer applied, and then moving the cold block 10 into contact with the heated block 6. As the two blocks 6 and 10 are brought into thermal contact, the block 6 and hence the reaction vessels are cooled by the block 10.

The blocks 6 and 10 may be brought into contact by any suitable means. For example, either or both of the blocks 6 and 10 may be arranged to be moveable. However, it is preferred to provide supports, as indicated at 20, for the cold block 10 which can be actuated by suitable means, indicated at 22, to lift the cold block 10 into contact

with the heated block 6. The supports 20 may be arranged to lift the cold block 10 alone, the cold block 10 together with the Peltier elements 12, or the cold block 10, the elements 12 and the heat sink 14 as a unit. Any of the elements 12 or the heat sink 14 not raised by the supports 20 are left in their original position.

It will be appreciated that the apparatus shown in Figure 1, which may be implemented as required, has a number of advantages over known arrangements for heating and/or cooling material, particularly where Peltier elements are to be used to provide the cooling effect. Thus, the Peltier elements 12 are never subjected to the temperatures reached by the reaction vessels of the plate 4 or of the heated block 6. This reduces thermal stress on the Peltier elements 12. Furthermore, as the heated block 6 is required only to provide a thermally conductive path for the reaction vessels, its mass can be kept to a minimum. The cold block 10 may be cooled continuously whilst it is spaced from the heated block 6. This means that it is not necessary to switch the current supply to the Peltier elements 12 on and off as in some present arrangements, thereby reducing thermal stress thereon. This also means that the cold block 10 can be efficiently cooled to a very low temperature, and thus enable high heat extraction rates to be achieved.

Figures 2 and 3 show an end view and a side view of a preferred embodiment of apparatus of the invention in which the actuating means 22 for lifting the cold block 10 incorporates a flexible bellows assembly. In Figures 2 and 3, the same reference numerals have been used as in Figure 1 to refer to the same or similar parts.

The apparatus shown in Figures 2 and 3 comprises a housing 30 supporting the heated block 6 to extend

substantially horizontally near the top of the housing 30. This heated block 6 carries the reaction plate 4 which is arranged to receive a plurality of test tubes (not shown) in a number of individual supports 32 provided. The cold block 10 is mounted on top of four push rods 20. It will be seen that the lower end of each push rod 20 is fixed to a bellows plate 34. This plate 34 is received within a channel member 36 fixed to a lower part of the housing. The channel member 36 has a fixed end plate 38 which is spaced above the bellows plate 34 and extends substantially horizontally of the housing 30. Two bellows 40 are provided and are each fixed between the moveable bellows plate 34 and the fixed end plate 38. Each bellows 40 is provided with an appropriate outlet pipe 42 for connection to a vacuum pump. It will be appreciated that as each bellows 40 is evacuated by way of its outlet pipe 42, it is caused to collapse. This collapse of each bellows 40 moves the bellows plate 34 upwardly towards the end plate 38 whereby the rods 20 are lifted within the housing 30 and thereby lift the cold block 10.

In the embodiment of Figures 2 and 3 it is the cold block 10 alone which is to be lifted, the heat sink 14 and the Peltier elements 12 being mounted at a fixed position within the housing 30. In this respect, it is clearly apparent from Figures 2 and 3 that each of the Peltier elements 12 and the heat sink 14 are provided with appropriate bores for the passage therethrough of the push rods 20.

The use of an actuating mechanism 22 incorporating one or more bellows assemblies as 40 means that the push rods 20 are each flexibly mounted and may therefore exert evenly distributed pressure on the cold block 10. Variations and tolerances may easily be accommodated.

Of course, any means may be provided to lift the push rods 20 so long as they are lifted together so that substantially all of the top surface of the cold block 10 is brought into contact with the heated block 6 for maximum heat transfer. For example, the push rods 20 may be lifted by one or more solenoid valves, one or more pneumatic or hydraulic cylinders, or by way of a motor and appropriate linkages.

It will be appreciated that in some situations, particularly if the cold block 10 is cooled below the dew point, it is advantageous to surround the cooling elements 12 and the cold block 10 by a gaiter, for example, of rubber. This will prevent condensation forming.

It will be appreciated that other variations and modifications to the invention may be made within the scope of this application.

CLAIMS

1. Apparatus for heating and/or cooling reaction vessels comprising a thermally conductive support member for said reaction vessels, a first thermally conductive block, and means for causing relative movement between said first thermally conductive block and said support member between a first position in which said first block and said support member are in thermal contact, and a second position in which said first block and said support member are spaced apart, and further comprising first means for heating and/or cooling said first thermally conductive block.

2. Apparatus as claimed in Claim 1, wherein said first means for heating and/or cooling said first thermally conductive block comprises first cooling means arranged to cool said first thermally conductive block such that said first relative position of said first block and said support member is a cooling position, and said second position, in which said first block and said support member are spaced apart, is a non-cooling position.

3. Apparatus as claimed in Claim 2, wherein said first cooling means comprises a plurality of Peltier elements arranged to be in thermal contact with said first thermally conductive block, at least in the second position of said first block and support member.

4. Apparatus as claimed in Claim 3, wherein a surface of said first block remote from said support member is arranged to contact a first surface of said plurality of Peltier elements, and wherein said plurality of Peltier elements are provided with contact means for connection to a power source whereby electrical power may be applied to said elements such that said first surface thereof is cooled.

5. Apparatus as claimed in Claim 4, wherein a heat sink is provided and is arranged, at least in said second position of said first block and said support member, to be in contact with a second surface of said plurality of Peltier elements remote from said first surface.

6. Apparatus as claimed in Claim 5, further comprising air flow generating means arranged to cause an air flow through or across said heat sink.

7. Apparatus as claimed in any preceding claim, wherein said thermally conductive support member comprises a second thermally conductive block, and second means are provided for heating said second thermally conductive block.

8. Apparatus as claimed in Claim 7, wherein said second heating means comprise an electrical heater.

9. Apparatus as claimed in Claim 8, wherein said electrical heater comprises a resistance wire provided in the second thermally conductive block.

10. Apparatus as claimed in Claim 8 or 9 wherein said electrical heater comprises a resistive film deposited onto an insulating substrate mounted within said second thermally conductive block.

11. Apparatus as claimed in any preceding claim, wherein said means for providing relative movement between said first thermally conductive block and said support member is arranged to move either the support member or the first thermally conductive block, or both of these members.

12. Apparatus as claimed in any preceding claim, wherein said support member is supported at a fixed position within a housing, said first thermally conductive block is mounted

within the housing beneath said support member, and said relative movement providing means comprises means for moving said first thermally conductive block between the first, upper, position, in which it contacts the underside of said support member, and the second, lower, position in which it is spaced from said support member.

13. Apparatus as claimed in Claim 12, wherein said first means for cooling the first thermally conductive block comprises a plurality of Peltier elements, a lower, heated surface of said Peltier elements being in contact with and supported by a heat sink mounted within the housing.

14. Apparatus as claimed in any preceding claim, wherein said means for moving the first thermally conductive block comprises one or more rods coupled thereto such that lifting or extension of the rods lifts the block to its first position.

15. Apparatus as claimed in Claim 14, wherein said rods are arranged to be lifted and lowered by way of one or more bellows assemblies.

16. A method of heating and/or cooling material, the method comprising cooling material in reaction vessels supported by a support member, and the method comprising the steps of cooling a first thermally conductive block, and moving the cooled, first thermally conductive block into contact with said support member such that it is thermally coupled to said reaction vessels and thereby cools them.

17. A method of heating and/or cooling material as claimed in Claim 16, wherein said first block is cooled by contacting a surface of said first block remote from said support member with a first surface of a plurality of

Peltier elements, and applying current to said elements such that said first surface thereof is cooled.

18. A method as claimed in Claim 17, wherein a heat sink is arranged in contact with a second surface of said Peltier elements remote from said first surface and air is caused to flow across said heat sink, and wherein said first block is cooled when spaced from said support member.

19. A method as claimed in Claim 17 or 18, further comprising the step of heating said support member when said first thermally conductive block is spaced therefrom.

20. A method as claimed in Claim 19, wherein said first thermally conductive block and said support member are arranged spaced apart, and said support member is heated, and at the same time electrical current is applied to said plurality of Peltier elements to provide cooling to said first thermally conductive block.

21. Apparatus for heating and/or cooling reaction vessels substantially as hereinbefore described with reference to the accompanying drawings.

22. A method of heating and/or cooling reaction vessels substantially as hereinbefore described with reference to the accompanying drawings.

atents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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Relevant Technical fields

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F4H (H4)

(ii) Int Cl (Edition 5) H01L, F25B

Search Examiner
R C HRADSKY

Databases (see over)
(i) UK Patent Office

(ii)

Date of Search
29 OCTOBER 1992

Documents considered relevant following a search in respect of claims 1-22

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
A	GB 2128808 A (PLANER PRODUCTS) Figure 2	1

Category	Identity of document and relevant passages	Relevant to claim(s.

Categories of documents

X: Document indicating lack of novelty or of inventive step.

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P: Document published on or after the declared priority date but before the filing date of the present application.

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